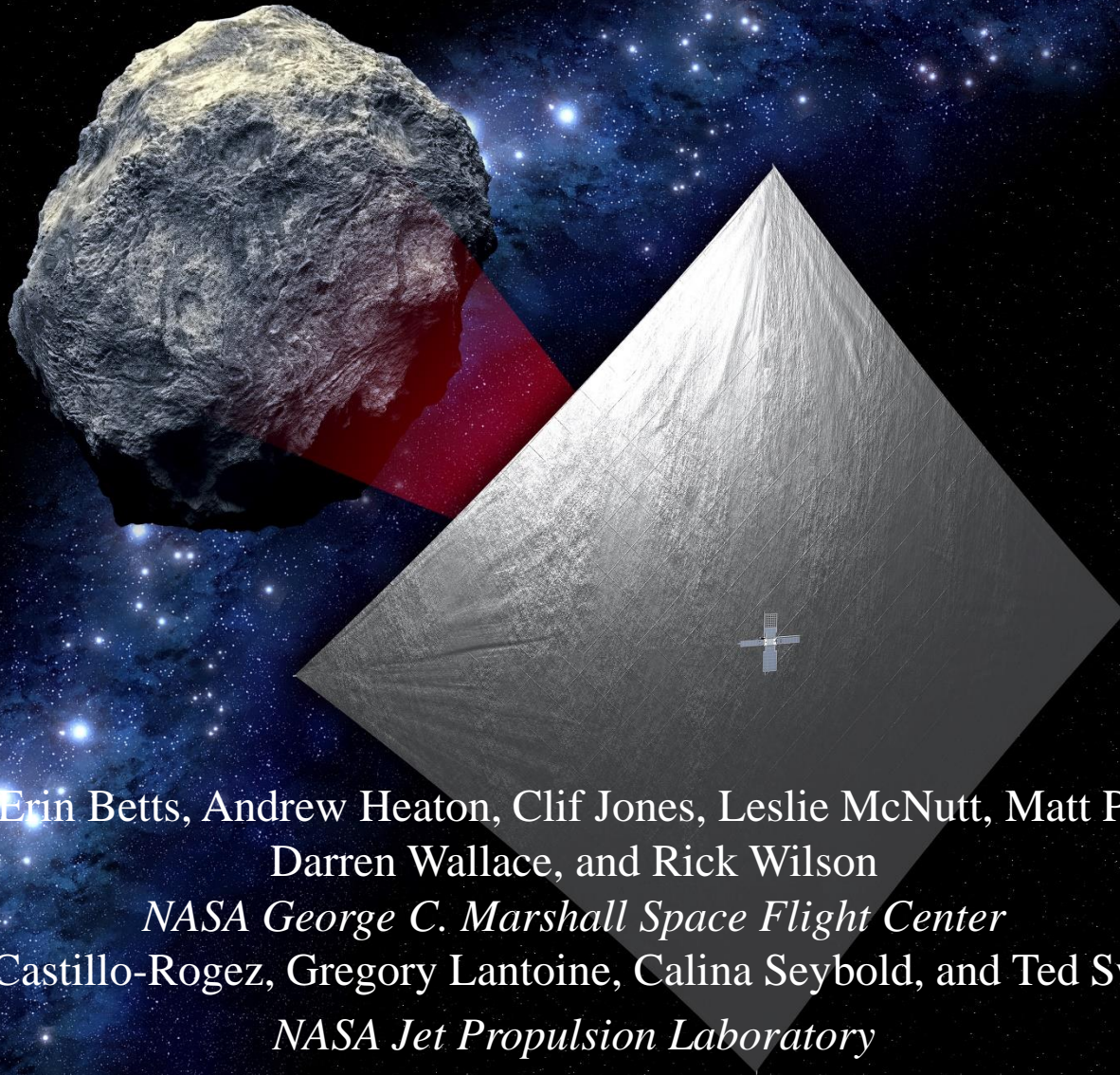


Near Earth Asteroid Scout (NEA Scout): Mission Update

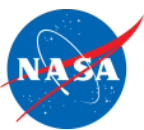


Les Johnson, Erin Betts, Andrew Heaton, Clif Jones, Leslie McNutt, Matt Pruitt, Jim Stott,
Darren Wallace, and Rick Wilson

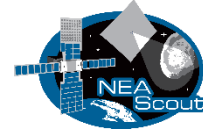
NASA George C. Marshall Space Flight Center

Julie Castillo-Rogez, Gregory Lantoine, Calina Seybold, and Ted Sweetser

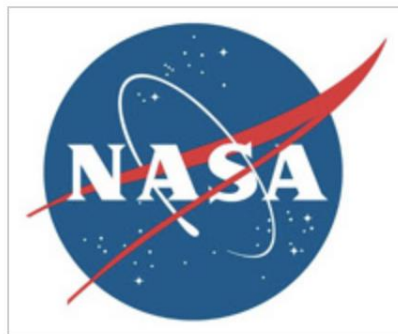
NASA Jet Propulsion Laboratory



NASA's Near-Earth Asteroid Scout (NEA) ready for Artemis I Launch



July 19, 2021 | 📱 📧



Pasadena, CA – NASA's Near-Earth Asteroid Scout (NEA) is tucked away safely inside the agency's powerful Space Launch System (SLS) rocket at NASA's Kennedy Space Center in Florida. The solar sailing CubeSat is one of several **secondary payloads** hitching a ride on **Artemis I**, the first integrated flight of the agency's SLS and the Orion spacecraft.

NEA Scout, a small spacecraft roughly the size of a large shoebox, has been packaged into a

dispenser and attached to the adapter ring that connects the SLS rocket and Orion spacecraft.

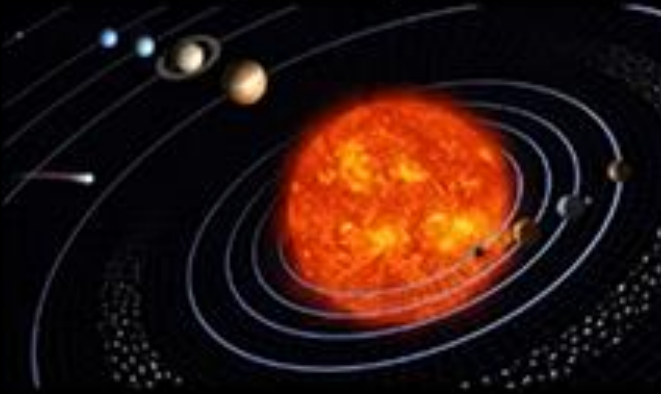


Engineers prepare NEA Scout for integration and shipping at NASA's Marshall Space Flight Center in Huntsville, Alabama. (NASA)

WHY EXPLORING NEAR EARTH ASTEROIDS?

Revealing Solar System History

SCIENCE



Mitigating Impact Hazards

DEFENSE



Enabling Human Exploration

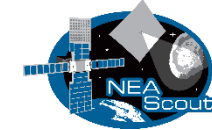
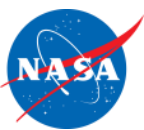
EXPLORATION



Developing a Space Economy

RESOURCES

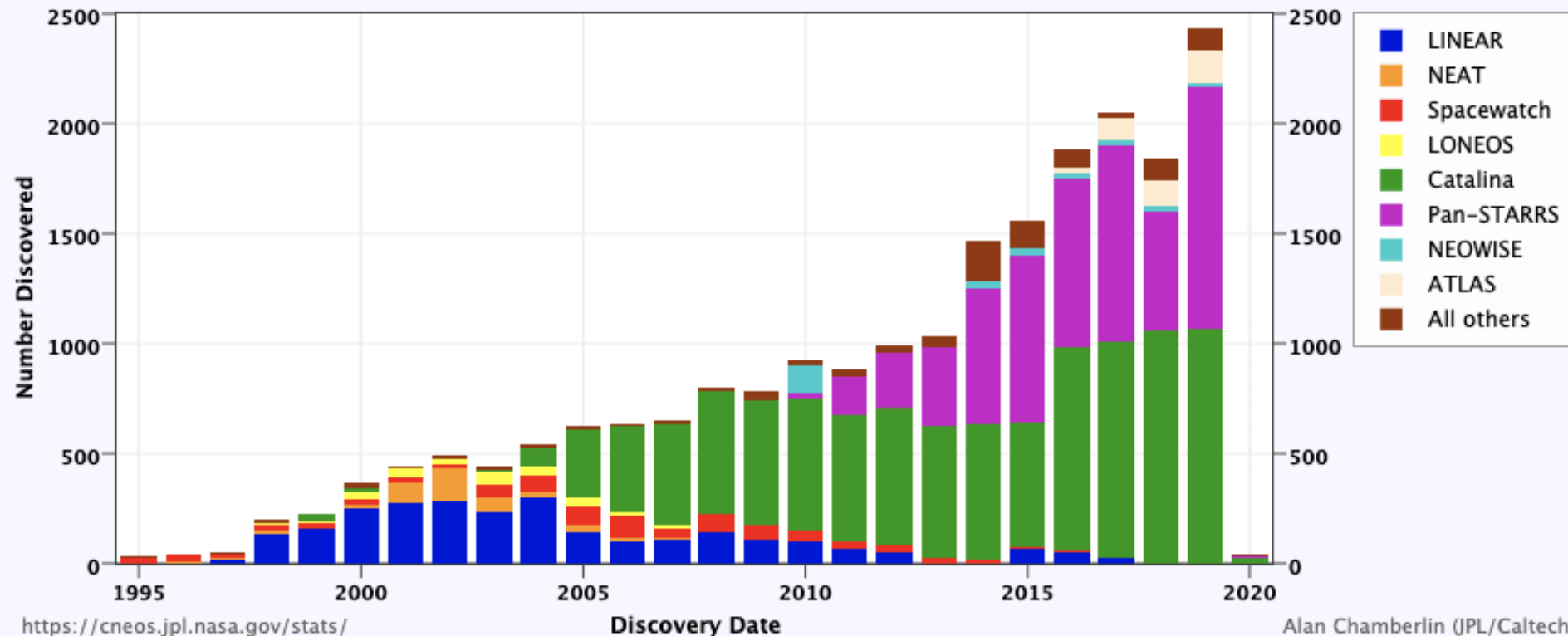




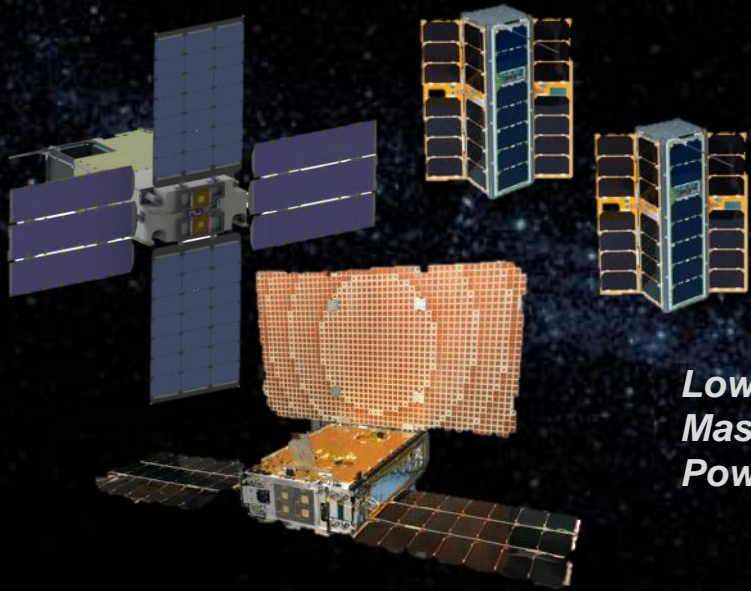
NEA Discoveries Have Been Exploding Over The Past Decade

Near-Earth Asteroid Discoveries by Survey

All NEAs (as of 2020-Jan-06)



TODAY

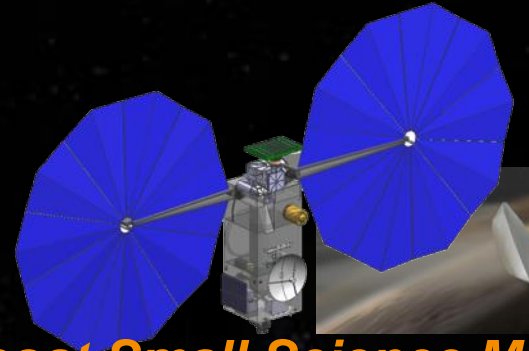


*Lower
Mass &
Power*

*Technology Demonstrations
Instruments and spacecraft components*

Near Earth Asteroid Scout (NEA Scout): The USA's First Solar Sail Propelled Interplanetary Science CubeSat

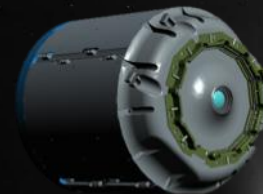
FUTURE



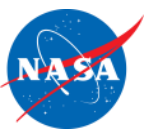
*Lower cost Small Science Missions
Inner solar system (≈\$100M)*



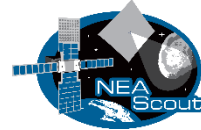
More Affordable Outer Planet Missions



Future Ocean World Probes

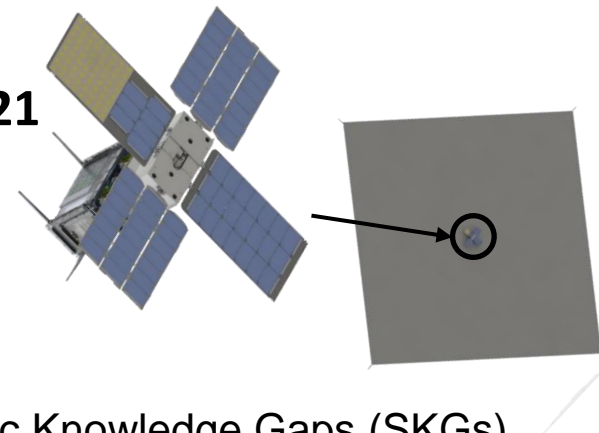


Near Earth Asteroid (NEA) Scout



1 of 10 CubeSats to launch with Artemis-1 in the Fall 2021

- Selected in 2013, MCR in 2014, Design Review in 2016
- Fully integrated and tested, delivered in July



GOALS – Science and Technology Demonstration

- Characterize a NEA with an imager to address key Strategic Knowledge Gaps (SKGs)
- Demonstrates low cost reconnaissance capability for HEOMD (6U CubeSat)

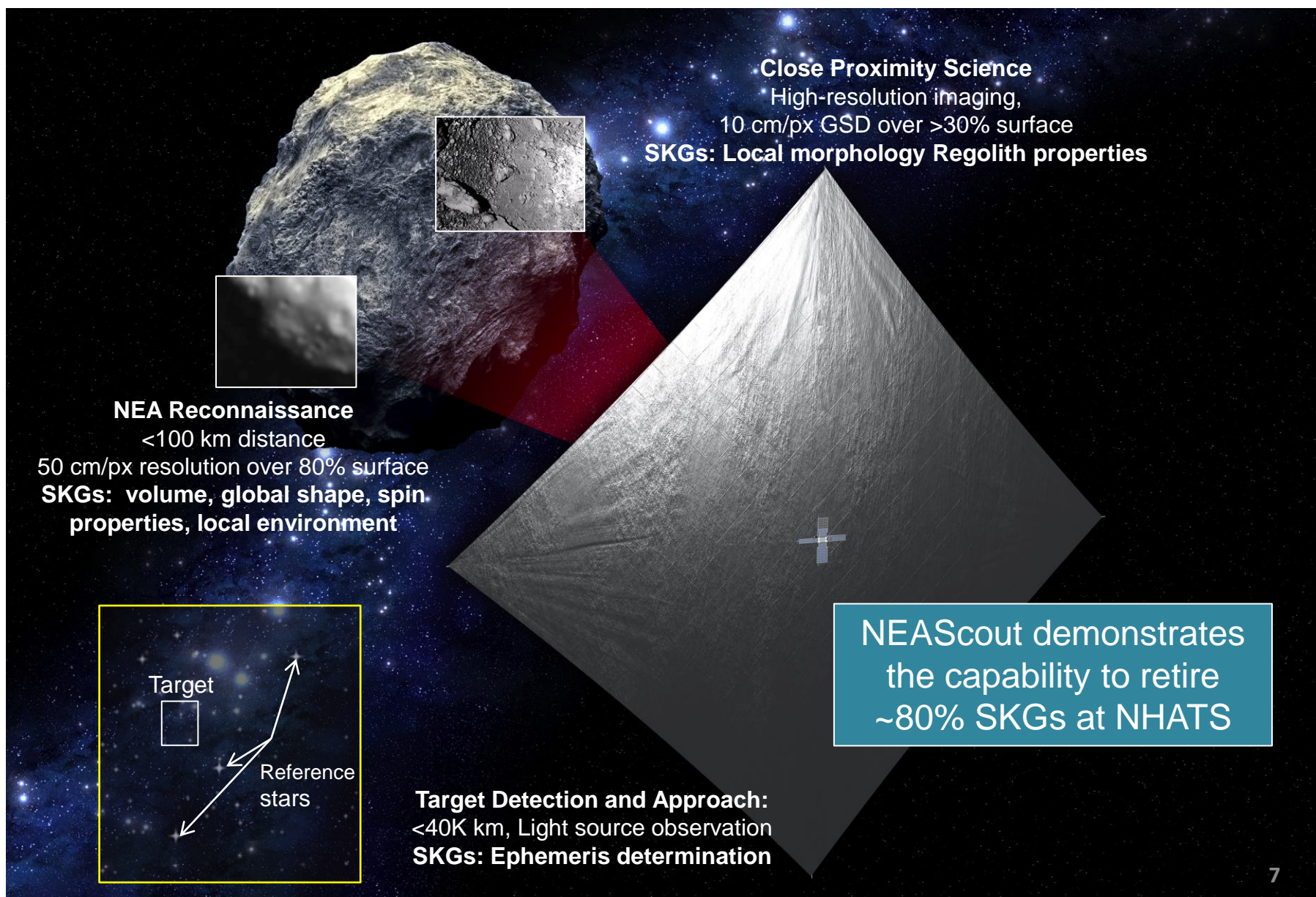
LEVERAGES:

- Solar sail development expertise (NanoSail-D, Solar Sail Demonstration Project, LightSail-A/B)
- CubeSat developments and standards (MarCO, University & Industry experience)
- Commonalities with other AES secondary payloads (e.g., Lunar Flashlight)

Key Technical Constraints:

- 6U Cubesat and ~86 m² sail
- COTS drive mission duration <2.5 yr
- Target must be within ~1.0 AU distance from Earth due to telecom limitations
- Slow flyby (5-20 m/s) with target-relative navigation on close approach

Science Measurements



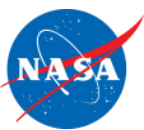
Close Proximity Science
High-resolution imaging,
10 cm/px GSD over >30% surface
SKGs: Local morphology Regolith properties

NEA Reconnaissance
<100 km distance
50 cm/px resolution over 80% surface
SKGs: volume, global shape, spin properties, local environment

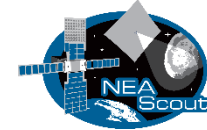
NEAScout demonstrates
the capability to retire
~80% SKGs at NHATS



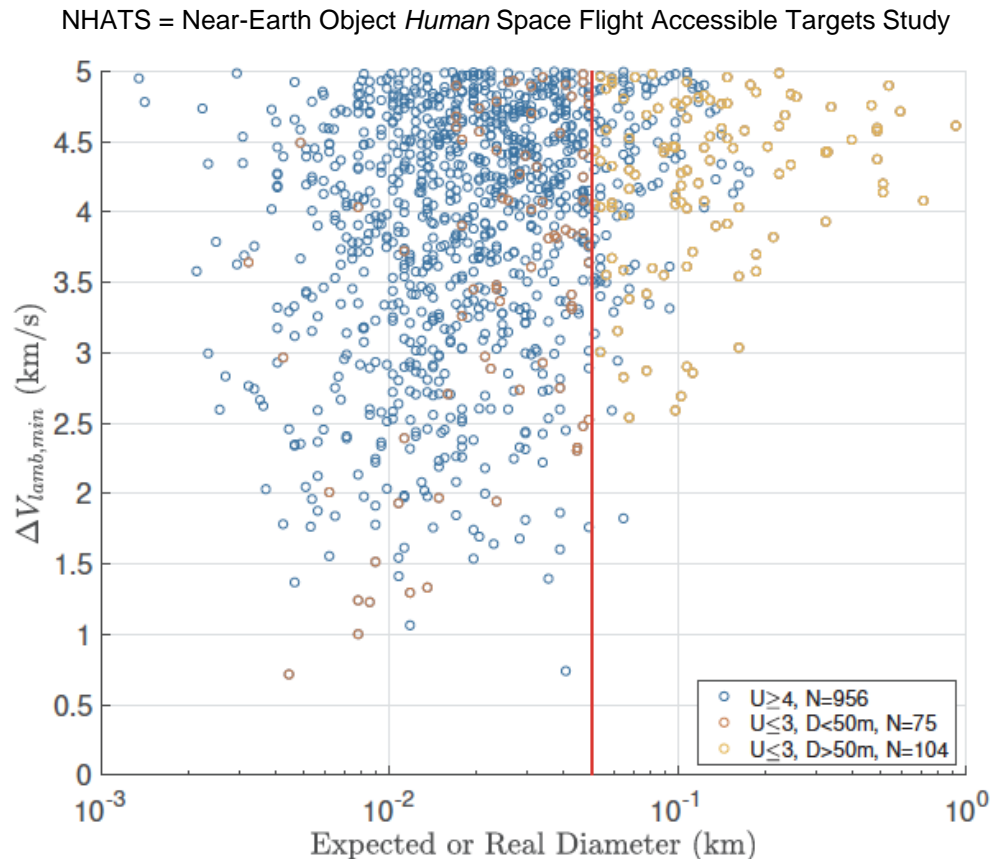
Target Detection and Approach:
<40K km, Light source observation
SKGs: Ephemeris determination



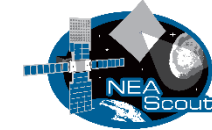
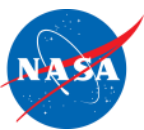
NEA Scout Targets NHATS



- NHATS database contains ~4000 targets from 1 m to >1 km
- Targets accessible to NEAScout are < 50m
- **About one target available for any launch window**
- Coordination with NEO Program Office at JPL (CNEOS) and astronomy community
- About 1 new accessible NEAs found each year
- NEAScout has the capability to reach challenging targets (H~28-29, OCC~1-2, telecom distance ~1 AU)

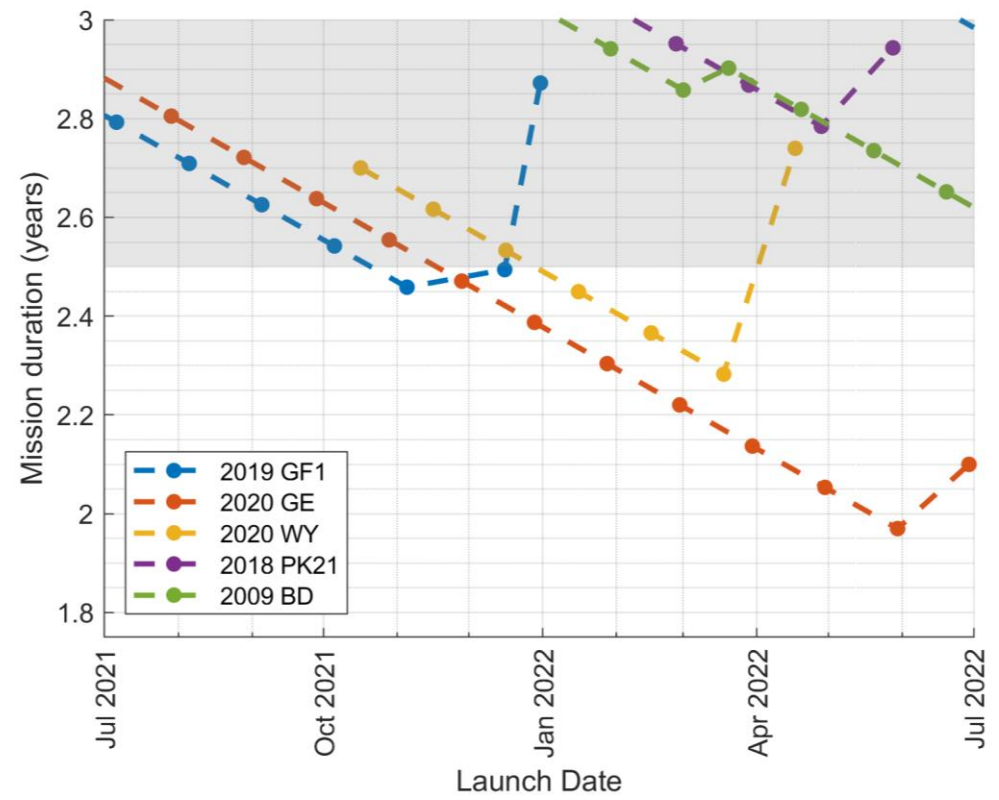


Currently accessible targets are well within NEAScout' capability



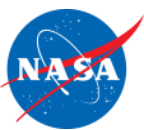
Baseline Target: 2020 GE

- Earth-crossing asteroid
- Potential “pebble” or lunar ejecta based on dynamical properties
- Magnitude $H=28.1 \rightarrow$ Diameter \sim 4-18 m (unknown albedo)
- Encounter in 11/2023, shortly after 2020 GE’s close Earth flyby
- Position is known within \sim 100s km
- **Telecom distance is \sim 0.15 AU at closest approach**
- Rotation period is unknown
- Unlikely to have a companion and retain a dust cloud

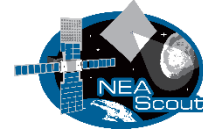


Data points assume:
 Optimal lunar escape (not designed yet)
 Medium-fidelity cruise (w/ 1-month margin)
 1-month approach
 6-month downlink

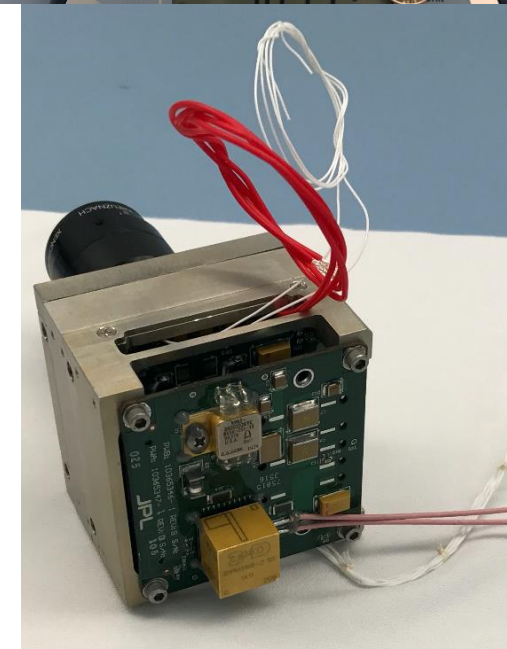
Baseline target is appealing for SKGs, Science, and Planetary Defense



NEA Scout Flies the Smallest Science-Grade, Deep-Space Camera

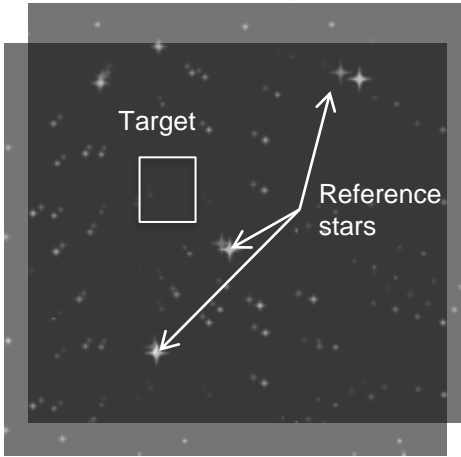


- ~ 400 gm, $1/2$ U, < 3 W, standard interfaces
- FOV ~ 27 deg., iFOV ~ 0.127 mrad
- 20 MPx EECAM detector (16 MPx usable)
- **Fully calibrated**
- Limitations: local storage of ~ 2 images; data transfer rate via SpaceWire is ~ 4.5 MPx/sec
- Flight spare on ATB
- Absolute photometric performance $< 1\%$
- Achieves 10 cm/pix from 800 m
- Doubles as Navigation camera
 - Detects H-28 target in a few 100s ms from > 40 K km



NEACam Meets or exceeds Science and NAV requirements

ACTIVITIES



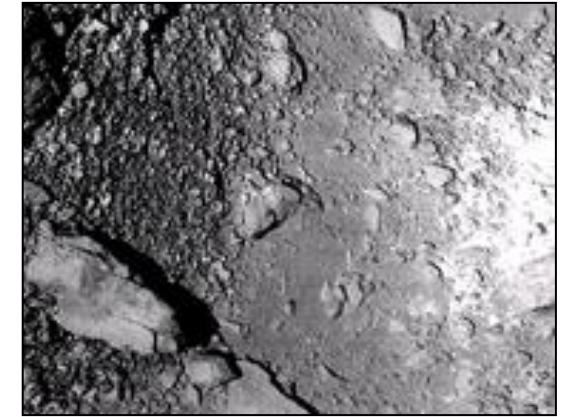
Target Detection and approach with wide field imaging

Ephemeris determination



Target Reconnaissance with medium field imaging

Shape, spin, and local environment



Close Proximity Imaging

Local scale morphology, terrain properties, landing site survey

CHALLENGES

Limited downlink (<4kbps)
Large target position uncertainty

Limited downlink (<1-4kbps)
Short flyby time (<60 min.)
Uncertain environment

Limited downlink (<1-4kbps)
Short time at closest approach (<20 sec.)

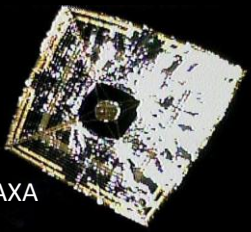
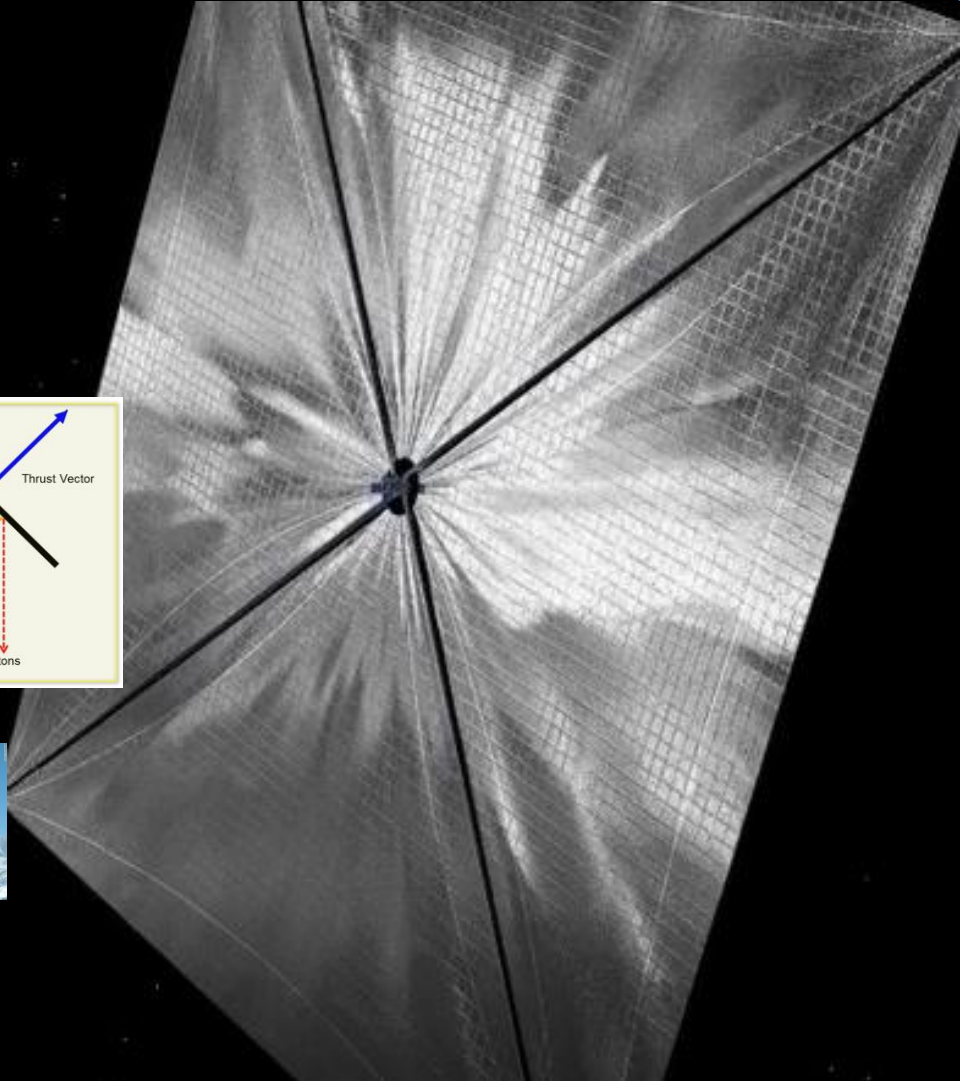
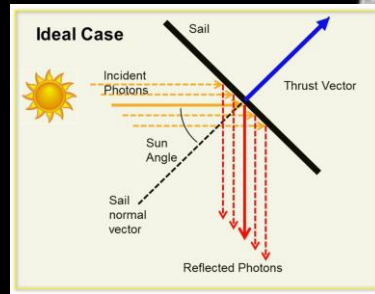
APPROACH

Capture position ellipse in one FOV
Image co-adding
subwindowing
Lossless Compression

Thumbnails, triage, lossless compression, subwindowing
Autonomous target pointing (center of brightness)

NEAS' approach to on-board data processing is a pathfinder for future autonomous missions

- Producing thrust with sunlight “pressure” or force on thin, lightweight, reflective sheets
- Allows space missions to new, propulsion-intensive locations



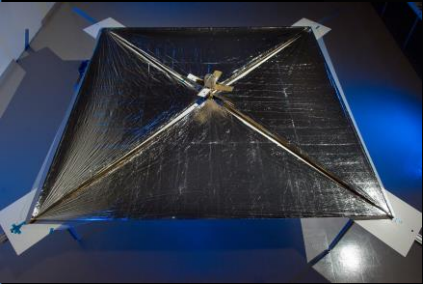
JAXA



The Planetary Society



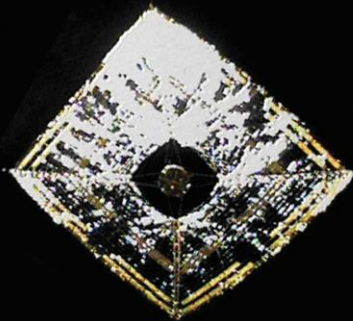
Solar Sail Missions Flown



NanoSail-D (2010)
NASA

Earth Orbit
Deployment Only

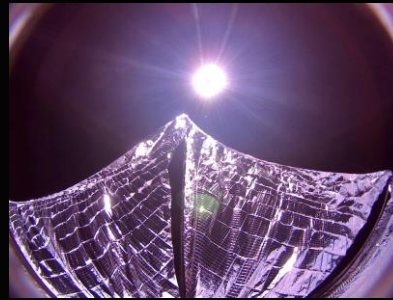
3U CubeSat
10 m²



IKAROS (2010)
JAXA

Interplanetary
Full Flight

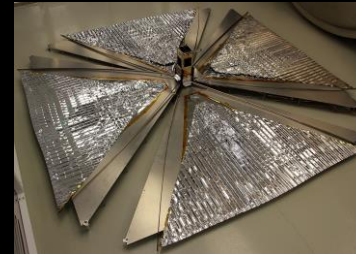
315 kg Smallsat
196 m²



LightSail-1 & 2
(2015/2019)
The Planetary Society

Earth Orbit
Deployment / Flight

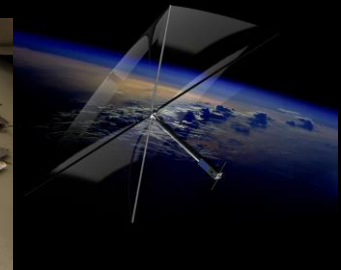
3U CubeSat
32 m²



CanX-7 (2016)
Canada

Earth Orbit
Deployment Only

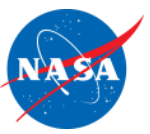
3U CubeSat
<10 m²



InflateSail (2017)
EU/Univ. of Surrey

Earth Orbit
Deployment Only

3U CubeSat
10 m²



NEA Scout Approximate Scale

Deployed Solar Sail



School Bus

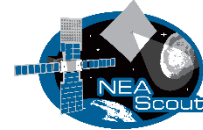
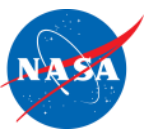


6U Stowed Flight System



Folded, spooled and packaged in here

Near Earth Asteroid Scout (NEA Scout): The USA's First Solar Sail Propelled Interplanetary Science CubeSat

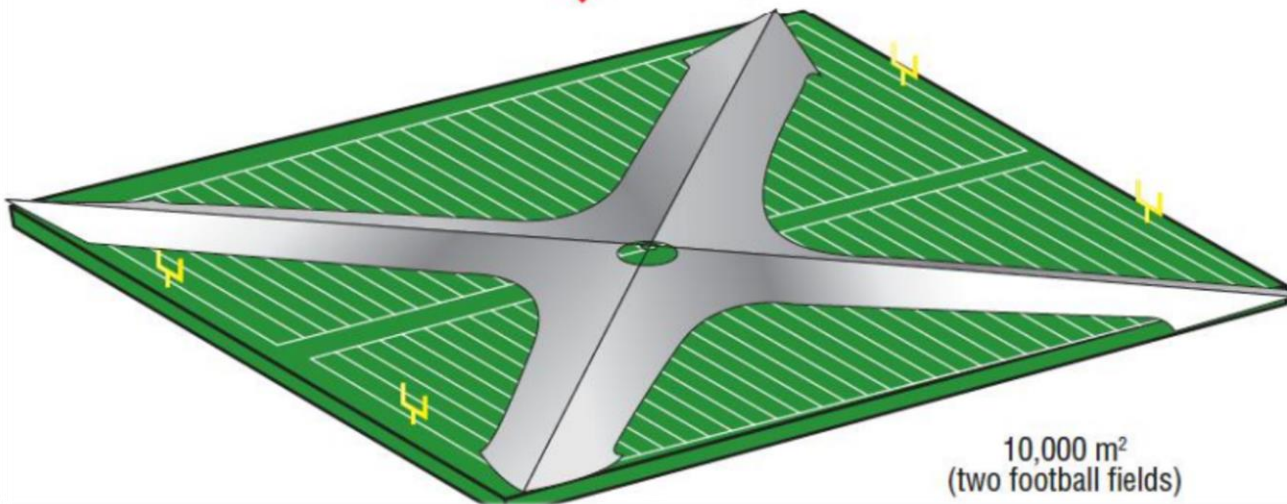


Solar Sails Experience VERY Small Forces and Reduce or Eliminate the Need for Propellant

- Force on a 100 m x 100 m square sail:

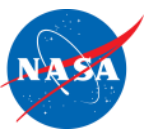


Solar Force Equivalent
at 1 AU

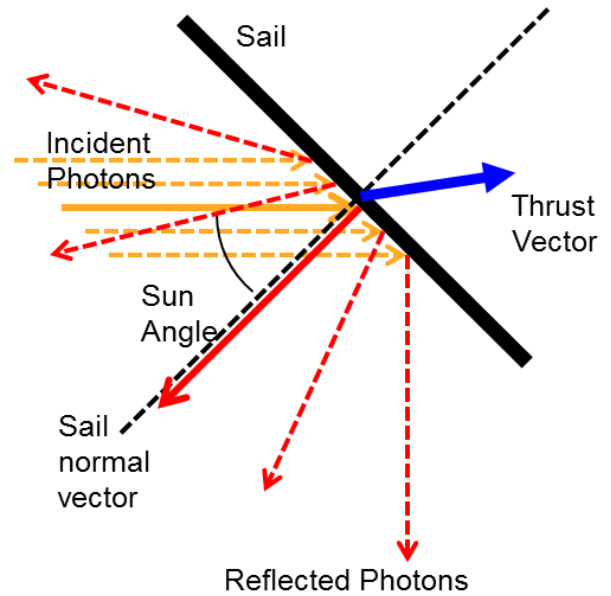
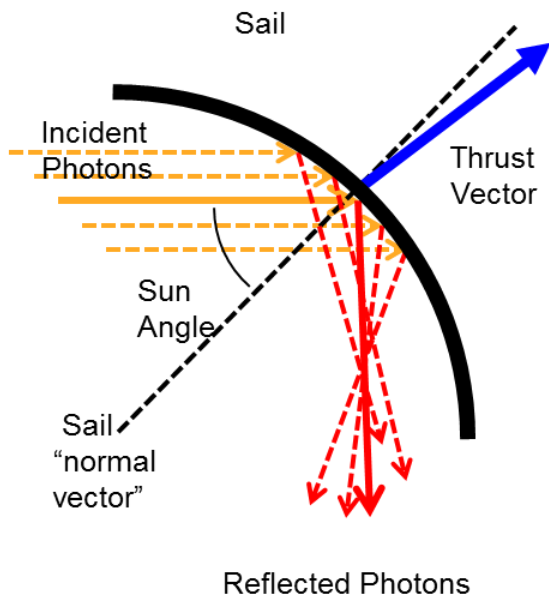
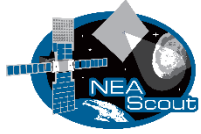


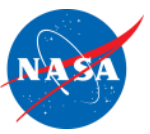
In 2.5 years of flight,
NEA Scout will
generate:

$$\Delta V = 3 - 5 \text{ km/sec}$$

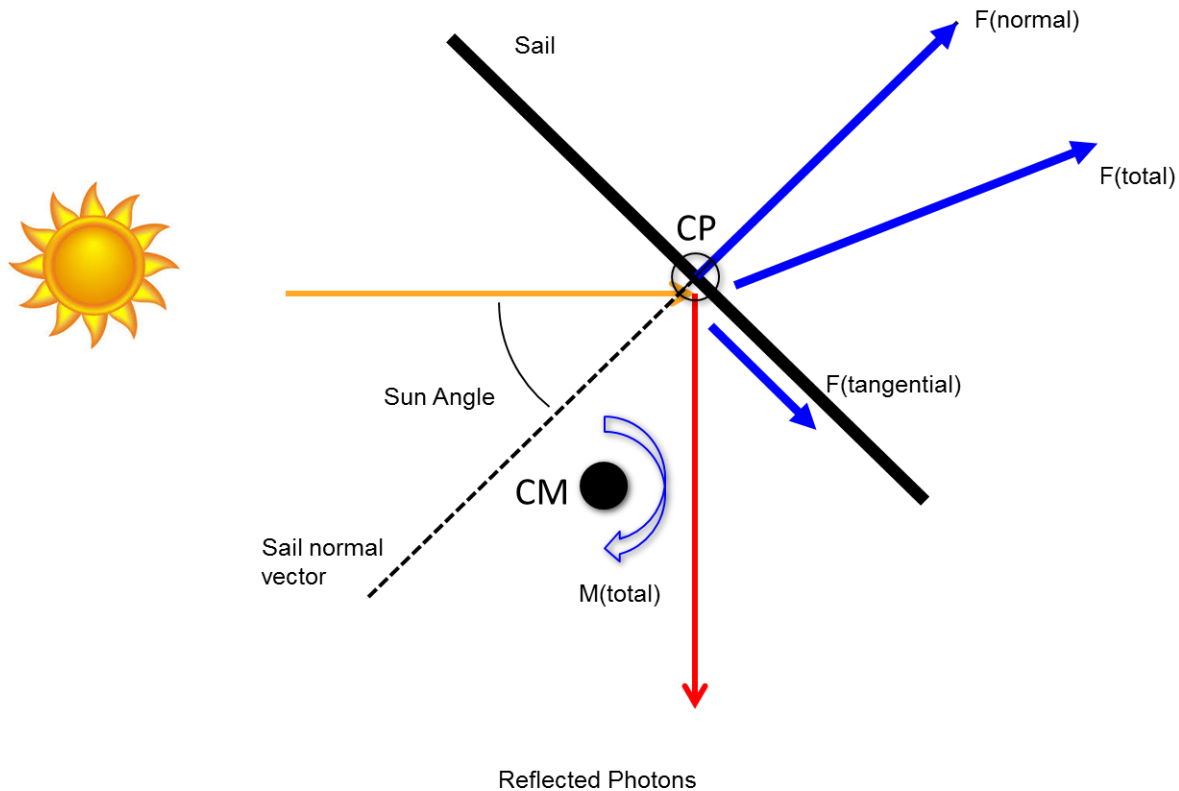
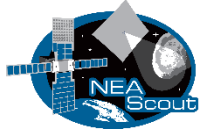


Real Solar Sails Are Not "Ideal"



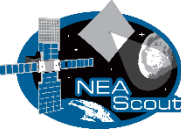


Thrust Vector Components and Momentum Management

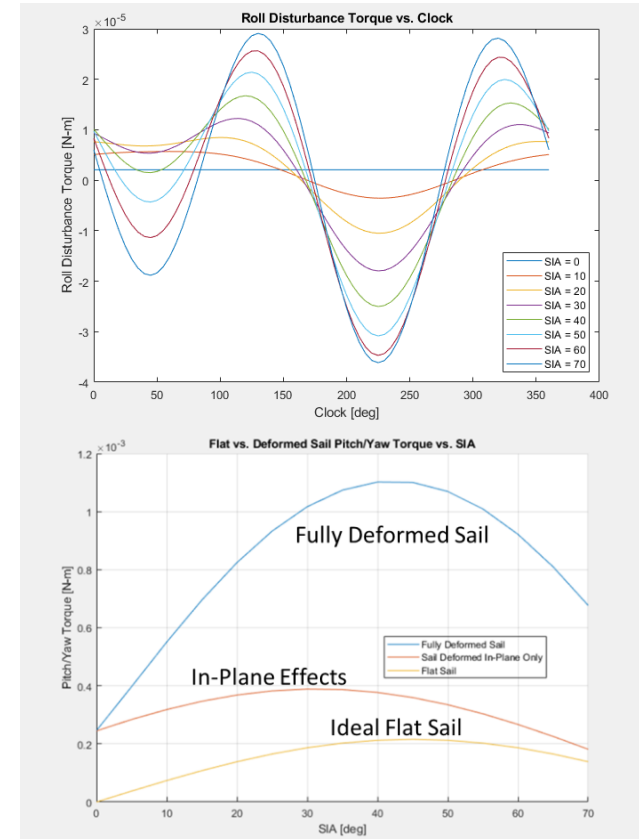


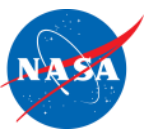


Attitude Control and Momentum Management Challenges

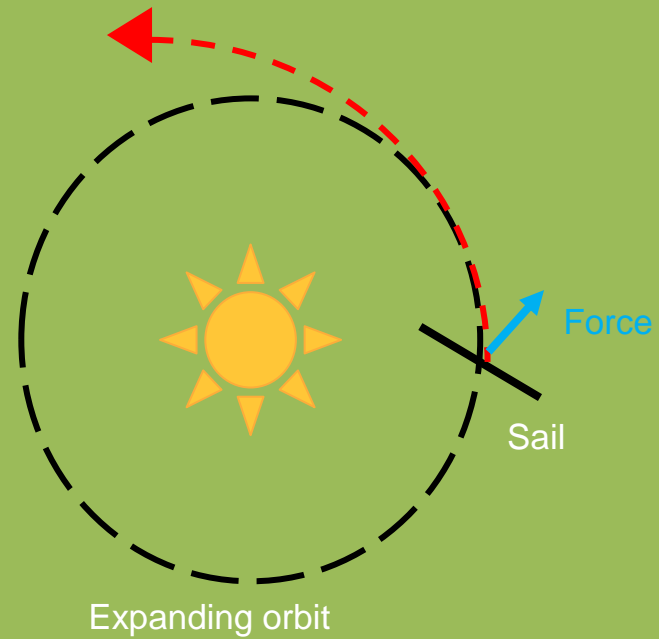
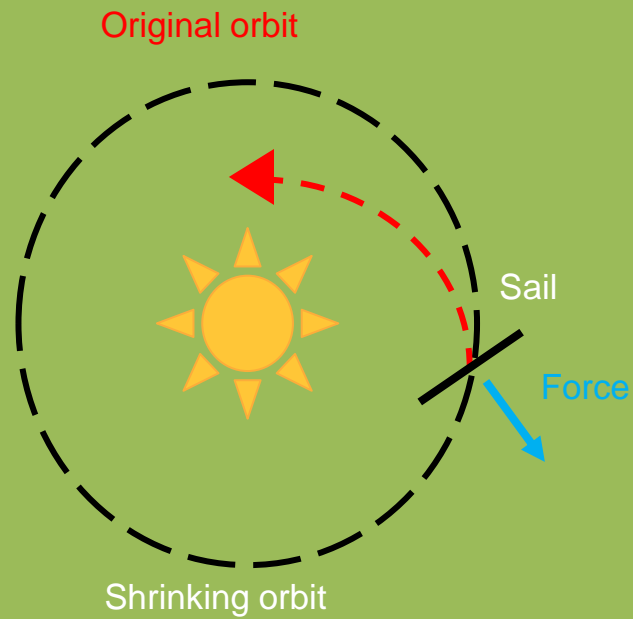


- Architecture must consider:
 - Highly-dynamic disturbances (e.g., flex dynamics) for finer pointing control.
 - Less dynamic solar disturbances.
 - Sun Incidence Angles and slew rates required for the mission and any clock angle constraints.
- Sail/boom deformations and CM/CP offsets must be considered to properly estimate solar disturbance torques for actuator sizing.
- Increasing sail area causes:
 - Greater peak solar disturbance torques.
 - Higher-amplitude and lower-frequency flex modes.
 - More inertia to accelerate for slewing.

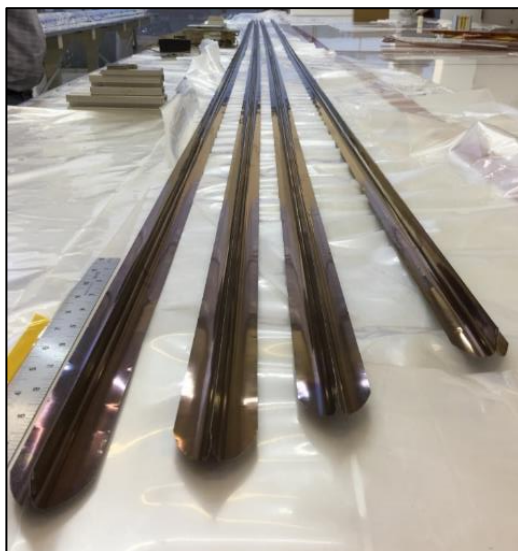




Solar Sail Trajectory Control



NEA Scout Flight Sail Deployment Tested



7.3 m booms



86 m² sail

Solar Sail Deployment Testing

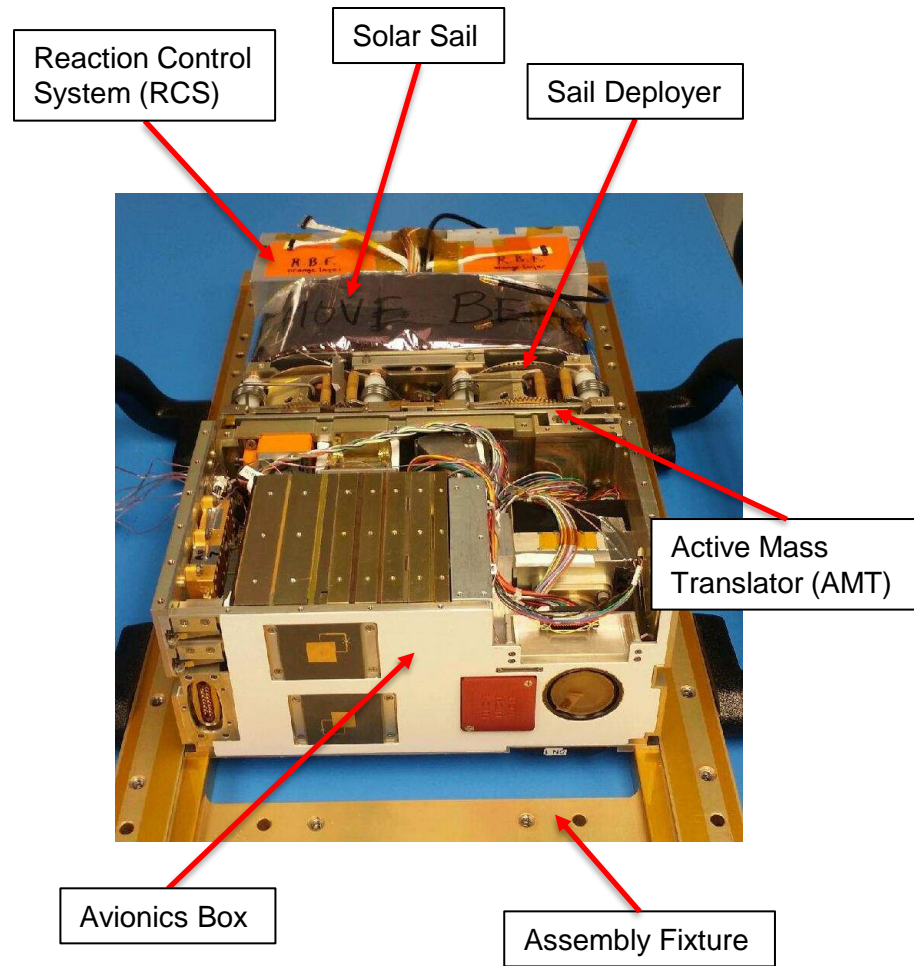


(Credit: National Geographic)

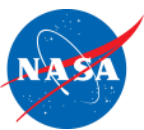
Folded Sail and Integrated Spacecraft



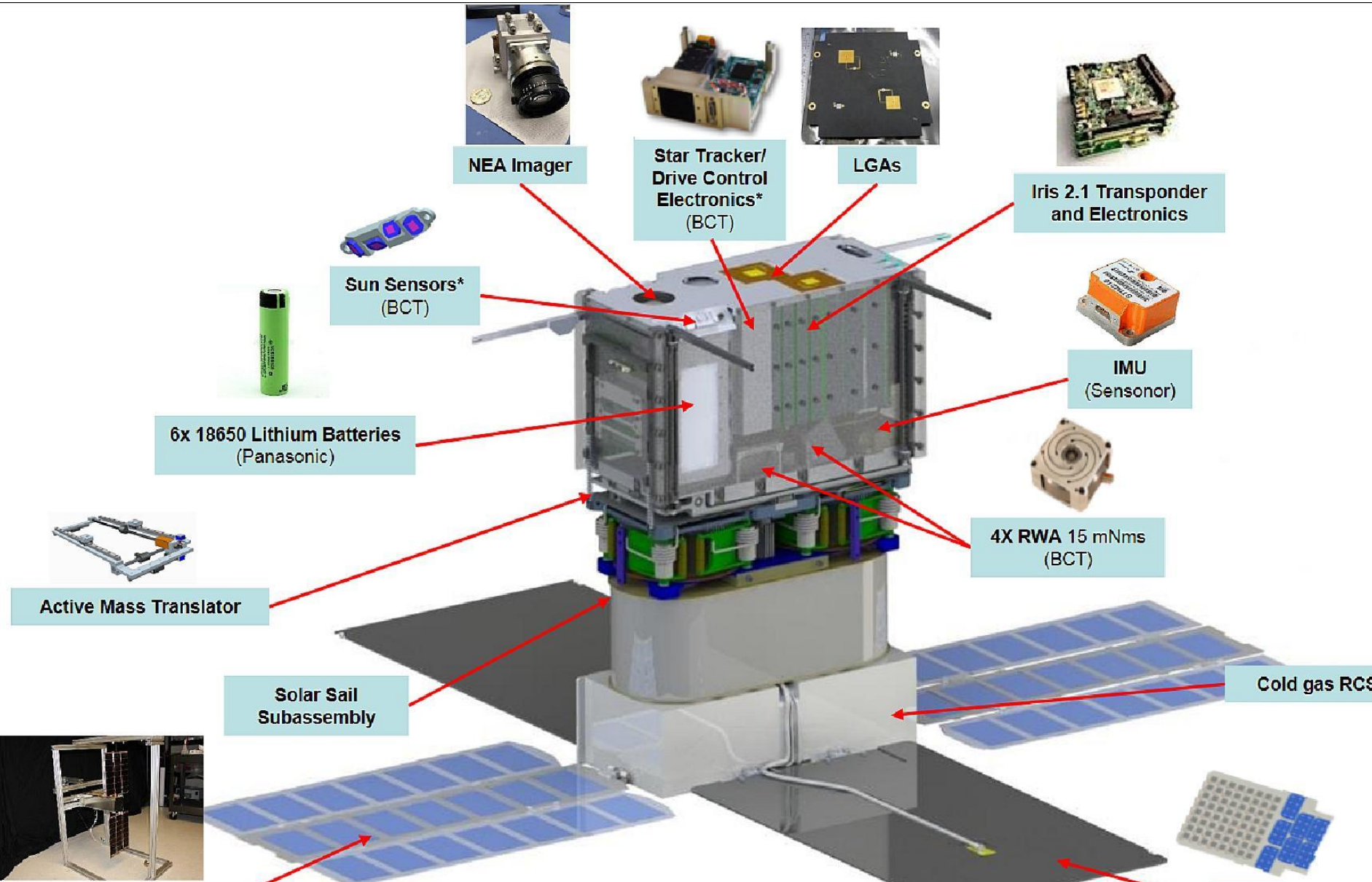
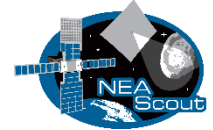
(Credit: National Geographic)



Integrated NEA Scout spacecraft on assembly fixture



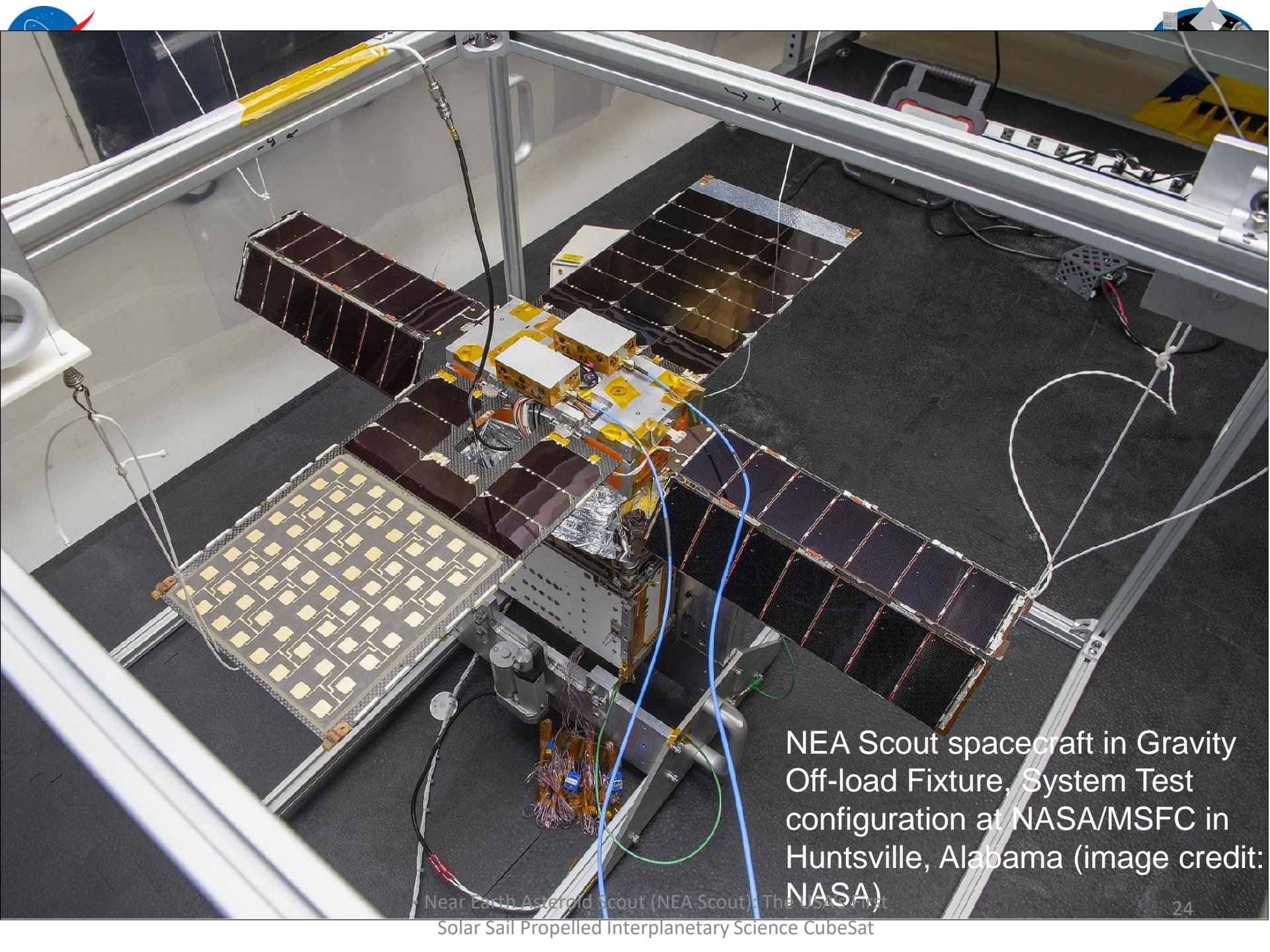
The Whole NEA Scout Spacecraft is Revolutionary



HAWK Solar Array (MMA)

Near Earth Asteroid Scout (NEA Scout): The USA's First Solar Sail Propelled Interplanetary Science CubeSat

MGA

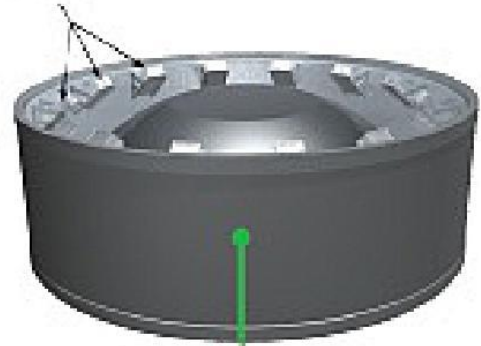


NEA Scout spacecraft in Gravity Off-load Fixture, System Test configuration at NASA/MSFC in Huntsville, Alabama (image credit: NASA)

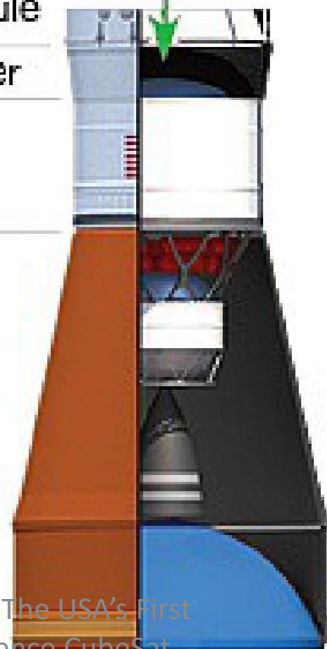


Orion Stage Adapter

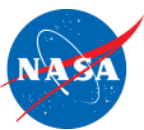
Secondary Payload locations



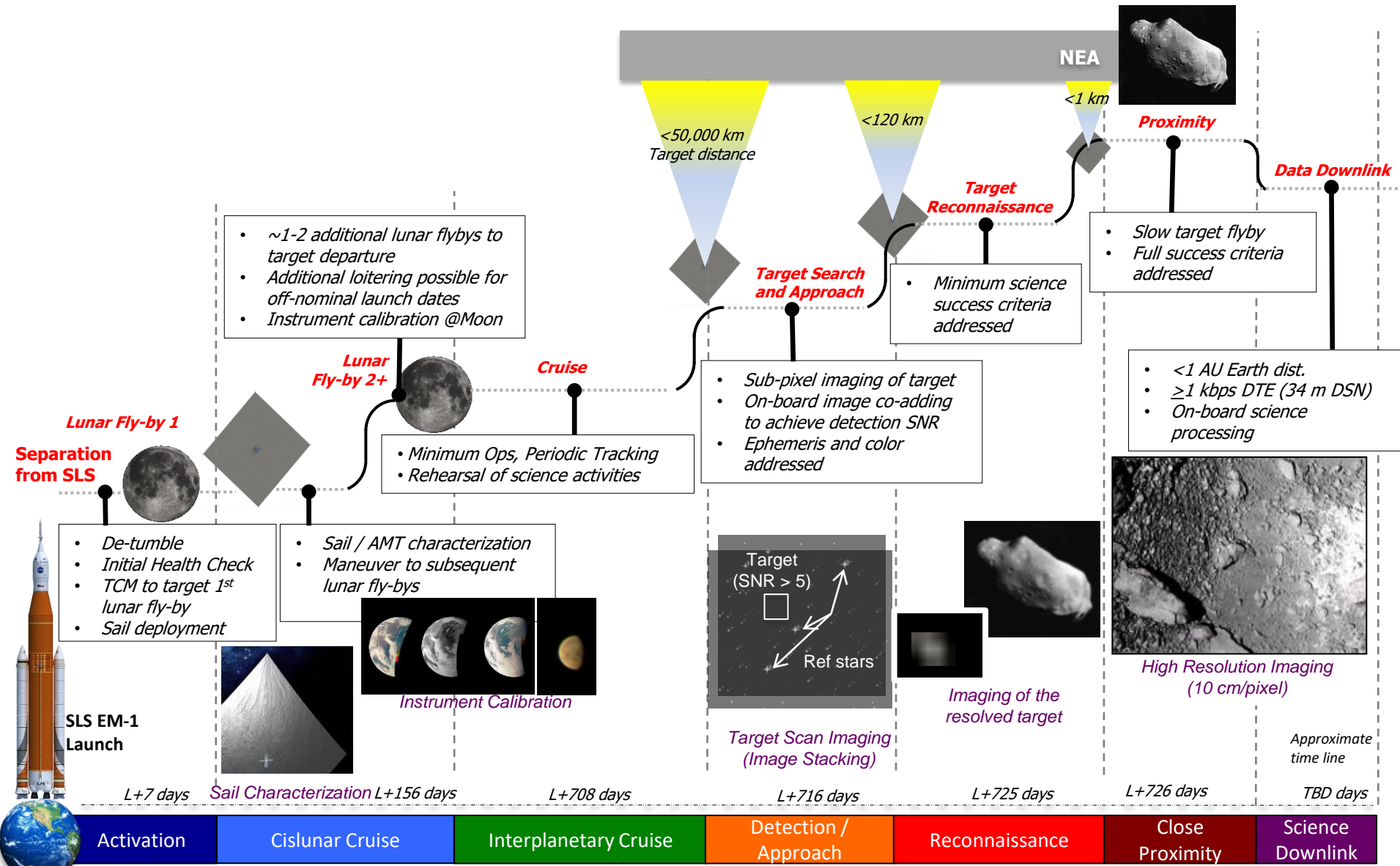
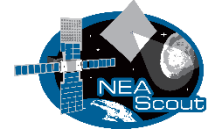
- Orion Service Module
- Orion Stage Adapter
- Interim Cryogenic Propulsion Stage
- Launch Vehicle Stage Adapter
- Core Stage



Near Earth Asteroid Scout (NEA Scout): The USA's First Solar Sail Propelled Interplanetary Science CubeSat

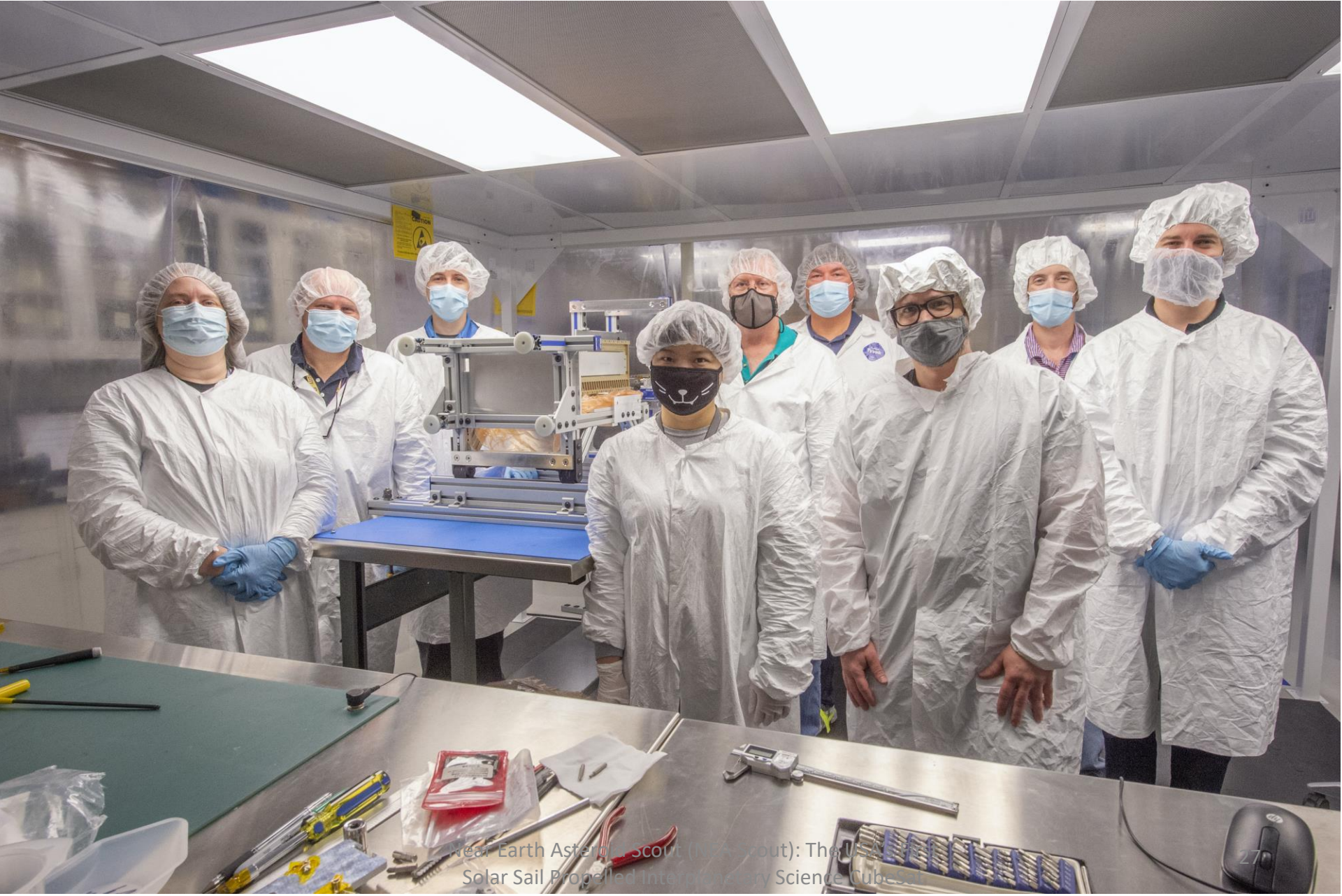


Concept of Operations (ConOps) Overview





THANK YOU NEA SCOUT TEAM!!!

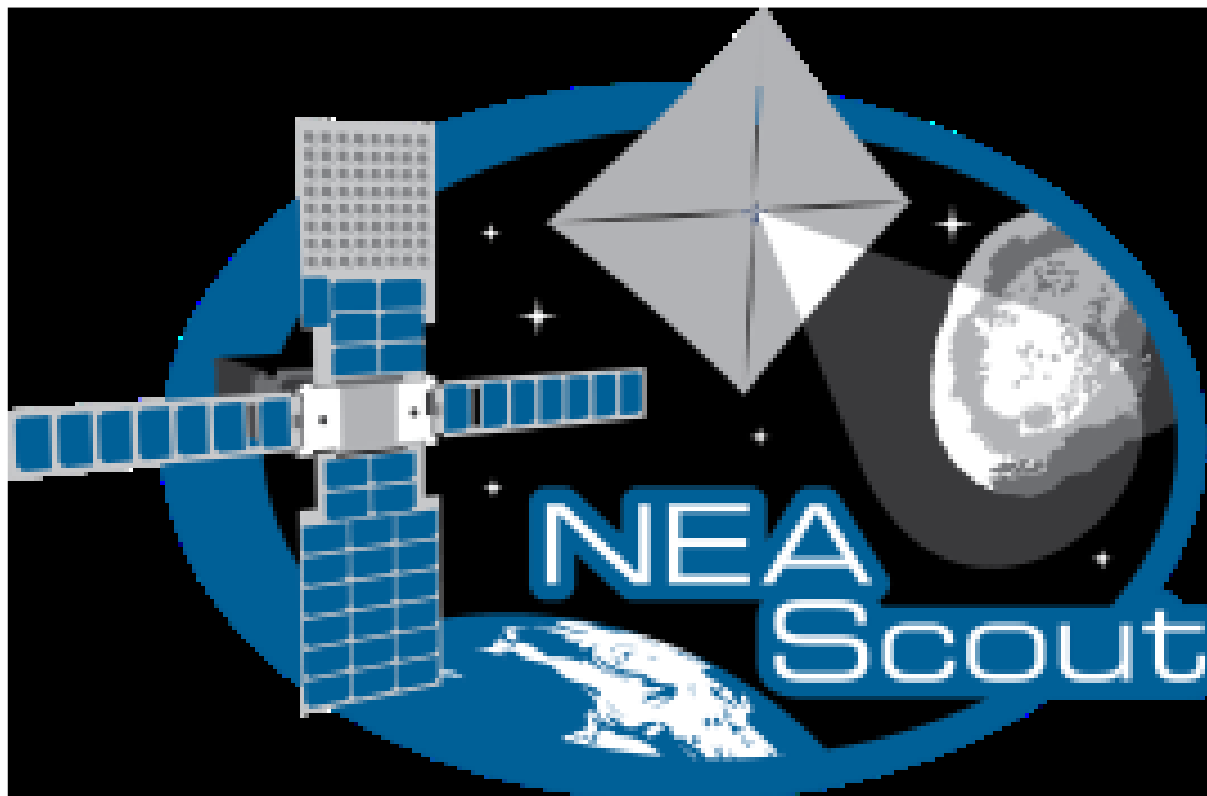
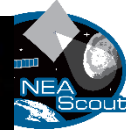


Near Earth Asteroid Scout (NEA Scout): The United States' First Solar Sail Propelled Interplanetary Science CubeSat

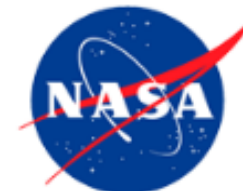


Human Exploration and Operations

Human exploration in and beyond low-Earth orbit



Jet Propulsion Laboratory
California Institute of Technology



**Marshall Space
Flight Center**



Science Principal Investigator: Julie Castillo-Rogez (JPL/Caltech)

Solar Sail Principal Investigator: Les Johnson (MSFC)

Project Manager: James Stott (MSFC); Deputy Project Manager: Calina Seybold (JPL/Caltech)

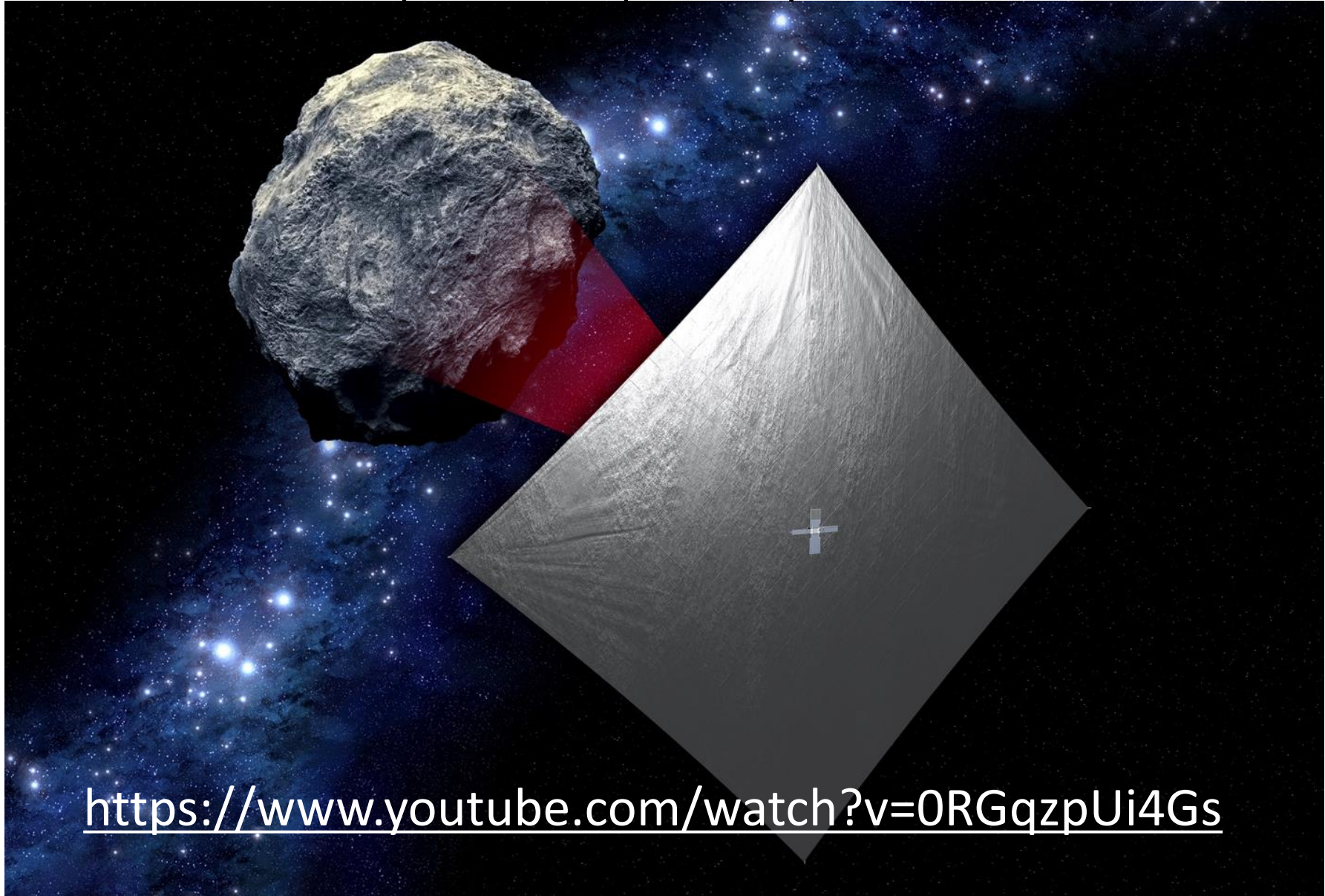
PSE: Matthew Pruitt (MSFC)

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<https://www.nasa.gov/content/nea-scout>



Near Earth Asteroid Scout (NEA Scout): The USA's First Solar Sail Propelled Interplanetary Science CubeSat



<https://www.youtube.com/watch?v=0RGqzpUi4Gs>